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by

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A STUDY OF NONPREGNANT DOLPHINS (*Stenella longirostris* AND *S. attenuata*) POSSESSING CORPORA LUTEA

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This contract was let to examine the possibility that dolphins involved in the eastern tropical Pacific tuna purse seine fishery have higher than normal abortion rates. To investigate this possibility the investigators examined the reproductive tracts of female dolphins with unexplained corpora lutea and compared them with controls where the reproductive status of the animal was known.

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ABSTRACT

This study of 58 nonpregnant uteri and ovaries of the Eastern spinner dolphin, Stenella longirostris (S.l.), and the spotted porpoise, Stenella attenuata (S.a.), was undertaken to ascertain whether ovulation can occur spontaneously. Control specimens of immature, pregnant and lactating females were examined also and were used to define the normal reproductive events in uterus and ovaries of these species. No differences were found between the two. In about half of the specimens we found active corpora lutea of recent origin and in another 15% (S.a.) and 29% (S.l.) corpora had fibrous centers but were hormonally active. No embryos were found and the endometrial changes were such that early but unobserved pregnancy could be excluded. In 35% of the specimens from S. attenuata the macroscopic diagnosis of corpus luteum was erroneous, while this was true of 21% in S.l. These corpora were degenerating and more resembled early corpora albicantia histologically. In two of these specimens, endometritis was found and the endometrial histology suggested abortion in three. These findings suggest that these Stenella species ovulate spontaneously, at least at times and that macroscopic classification of corpora lutea is frequently erroneous.

The reproductive physiology of the Pacific dolphin species (Stenella attenuata (S.a.) and Stenella longirostris (S.l.)) has not been fully elucidated. In particular, the question of whether these species have a copulation-induced (reflex) ovulation, as is suspected of other cetacea, needs resolution. In a detailed study of spotted porpoises (S.a.), Perrin et al. (1976) found that of 242 females with corpora lutea, 229 were pregnant. In a similar study of spinner dolphins (S.l.), Perrin et al. (1977) found that 2.8% of 536 adult females contained basically unexplained corpora lutea.

The distribution of species with and without reflex ovulation has been reviewed by Jöchle (1973). A surprisingly large number of species is listed as having exclusively or predominantly reflex ovulation, including cetacea. Only primates, mouse and rat are cited as exceptions in this respect. In several papers on camelidae reflex ovulation is well-supported by experimental studies and by observations from abbatoirs. Although camels and their South American relatives must be accepted as being reflex ovulators, the carefully controlled study by England et al. (1969) showed that "occasional spontaneous ovulation occurred during the height of the breeding season" in the llama.

In an attempt to gain additional information on the reproductive physiology of these two dolphin species, we examined the reproductive tracts of animals recorded to possess corpora lutea while not pregnant. Special attention was paid to ascertaining any reasons for the existence of these corpora lutea, such as early undetected pregnancy and an attempt was made to correlate the ovarian status with endometrial changes.

METHODS AND MATERIALS

Reproductive tracts of female dolphins Stenella longirostris (spinner

dolphin, S.l.) and Stenella attenuata (spotted dolphin, S.a.) were collected at sea by observers during commercial tuna fishing operations (Perrin et al. 1976, 1977). The organs were preserved in 10% formaldehyde solution and stored at the Southwest Bureau of Fisheries (SWBF), La Jolla, California. At the time of capture, a variety of observations were recorded including identified pregnancy, size of the fetus, and lactation. These data, dates and location of capture as well as related pertinent information are recorded in logs at SWBF. Here also the ovaries were thinly sliced and observations such as the presence of corpus luteum, corpora albicantia, and ovarian size were recorded and correlated with capture information. Those apparently nonpregnant uteri whose ovaries had a corpus luteum were dissected further and, occasionally, small fetuses were identified by SWBF staff. In addition, the present authors carefully dissected three intact uteri of 1977 catches where ovaries contained corpora lutea but in which pregnancy had not been recorded.

For the purpose of the present study the reproductive tracts of 53 non-pregnant dolphins, captured in 1976, and whose ovaries were recorded to contain corpora lutea were examined in detail. A few specimens of 1975 and 1977 were also studied and are included, bringing the figure to 58 genital tracts. The distribution of these is shown in Table 1.

While this represents the majority of specimens recorded to possess unexplained corpora lutea in 1976 (67 total), not all of the specimens were in suitable condition for inclusion in this study. Thus, several were too severely autolyzed for proper evaluation; in others, either the ovaries or uteri could not be located. The gross examination of genital tracts by us ascertained the following standard information: Weight; length and width of uterine horns and cervix; thickness of uterine walls at standard locations. Histologic

sections, stained with hematoxylin and eosin, were prepared from standard locations of tubes, uterine horns, lower uterine segments and ovaries as shown in Figure 1. Measurements of uterine mucosa and muscularis were made at low power microscopic examination with the aid of a calibrated ocular micrometer. At histologic examination the uterine findings (glands, secretion, mitoses, edema, hyalinization, inflammation) were compared with the ovarian activity. Relevant photomicrographs were made with a Zeiss Axiomat.

In addition to the material recorded above the following genital tracts were prepared as control material: Group I, 3 tracts of immature S.l.; Group II, 6 tracts of mature female S.l. having no corpus luteum and, therefore, termed "resting"; Group III, 12 tracts of S.l. with early pregnancy, the embryos measuring from 1 to 53 mm in length (1 - 5 gm with placenta); Group IV, 6 tracts of later pregnant dolphins (4, S.l. and 2 S.a.) with fetal sizes ranging from 300 - 725 mm; Group V, 11 tracts of lactating, nonpregnant females (10, S.l. and 1, S.a.); Group VI, the experimental group, 58 tracts of nonpregnant females possessing a corpus luteum (38 S.l. and 20, S.a.; Table 1). Thus, a total of 96 female genital tracts form the substance of this report.

Controls

Group I, Immature Females

These three S.l. measured from 164 to 176 cm and possessed neither corpora lutea (CL) nor corpora albicantia (CA). Because of their size it is assumed that they were at the verge of maturity. Measurements are given in Table 2. As shown in Figure 2, uterine horns were of equal size, there were no stretch marks and the endometrium was flat. Numerous Graafian follicles of varying stages of development were present in both ovaries, but there was no evidence of ovulation. The endometrium was thin and composed of tubular glands,

possessing neither secretion nor mitoses; the stroma was devoid of inflammation and edema or hyalinization (Figure 3). The fallopian tubes were small and empty. In all subsequent specimens, slides of fallopian tubes were examined. No relevant changes were observed and they are therefore not described further.

Group II, Mature Females

These 6 S.l. measured from 173 to 186 cm in length and were adjudged to be mature because of their size and the presence of at least one CA. They were not lactating nor did they possess a CL. The appropriate measurements are set forth in Table 3. In general, the horns were asymmetrical but not so markedly as those of lactating females (Group V), with the exception of #4 (Table 3). The wrinkled serosa and congestion of endometrium of this animal's left horn suggested recent pregnancy (Figure 4). All but one female of this group had "stretch marks" which were assumed to be an indication of previous pregnancy. Microscopic study of the corpora albicantia in this group allowed some correlation with the endometrial findings. Thus, the apparently most recently delivered uterus (Figure 4) had a still cellular CA (Figure 5) and inflammatory cells, hemosiderin macrophages and stromal hyalinization were observed in the congested endometrium (Figure 6). In the others, adjudged to have had past pregnancies, the CA was less cellular, more hyalinized and shrunken. The endometrium did not appear to be stimulated, had thin epithelium, no mitoses but scattered macrophages were in the process of removing debris. Apparently later still, Graafian follicle development commences, uterine horns are of nearly equal size and endometrial glandular redevelopment occurs with mitoses, glandular convolutions, occasional epithelial vacuoles and stromal edema (Figure 7).

Group III, Early Pregnancy

There were 12 S.1. in this group measuring from 166 to 188 cm in length (Table 4). With the exception of the first specimen listed, the left uterine horn was the larger. In this exceptional animal, the CL was also on the right and no CA was found in the left side. Uterine size and weight did not correlate well with embryonic size (1 - 53 mm) or weight (1 - 5 g). The conceptuses had been removed previously and had not apparently implanted yet. The larger (pregnant) horn had a congested endometrium and distended lumen (Figure 8).

This is an important control group for the experimental Group VI whose uteri were empty despite the presence of a CL. Thus, it is noteworthy that even in tiny conceptuses (Figure 9) the placental membranes are of appreciable size and they grow rapidly (Figure 10) so that they are difficult to overlook in dissections. Early limb bud development could be recognized in embryos sized 5 mm or more.

The cells of the CL of all of these animals were well-supported and the central fibrin clot was invaded by vessels and fibroblasts in all but one animal (#3, Table 4; Figure 9). This was also the smallest embryo other than that of the aberrant right specimen (#1, Table 4). Its CL is shown in Figure 11 and is readily distinguishable from the smaller luteal mass found in the experimental group.

The endometrium had characteristic changes that should allow the histologic diagnosis of early pregnancy. First, the tips of endometrial folds become edematous (Figure 12). At this stage the glands are empty and crowded in the basal portions. Their epithelium lacked mitoses. With advancing pregnancy the edema diminished while secretion accumulated in glands. Most characteristic, however, is the development of a rich capillary network with

congestion, most notably in the superficial strata (Figure 13). Despite the presence of significant chronic endometritis in two cases, normally developing early embryos were found.

Group IV, Late Pregnancy

We selected 4 S.l. and 2 S.a. between 165 and 199 cm in length and embryos of 300 - 725 mm in length (S.l.; the S.a. fetuses were lost at sea) for this comparison (Table 5). All implantations were in the larger left horn but a portion of the membranes traversed into the right horn. The large single corpus luteum of these 6 specimens was present in the left ovary.

The superficial endometrium was extremely arborized with distended glands into which the villi of the epitheliochorial placenta penetrated, forming an intimately interdigitating connection (Figure 14). The basal endometrium was edematous and glands contained secretion. With advancing gestation the villous arborization increased. The CL had characteristic appearance (Figure 15). Amongst the plump, eosinophilic luteal cells streamers of fibrocytes existed, giving the first appearance of degeneration. This connective tissue became less apparent with advancing pregnancy.

Group V, Lactating Females

Six specimens were selected measuring from 167 - 182 cm (S.l.) and one 202 cm (S.a.). They had been identified as lactating during dissection at sea. It is a heterogeneous group as judged by uterine size, endometrial histology and the appearance of the corpora albicantia (Table 6). Some animals must have delivered very recently as evidenced by the marked disparity of uterine horn size, hyperemia and the recent degenerative changes in the corpus luteum, while others had more equal horns and well-advanced corpora albicantia. No active

corpora lutea were present while at least one corpus albicans was found in all specimens. Some corpora albicantia had chronic inflammatory cell infiltration and four ovaries had Graafian follicles maturing at various stages. Stretch marks were present on the uterine serosa and the endometrium had typical involutional changes histologically. Beneath the surface epithelium there was a thin zone of hyalinization in most specimens, while recently delivered animals had prominent, congested vessels in myometrium and endometrium. Some of these had hyalinized walls also. In a majority of endometria a mild chronic inflammatory infiltrate was present; one had acute pyometritis. No mitoses or edema was present, the endometria appeared "resting". Hemosiderin-laden macrophages in endometrium or lower uterine segment were present in three, presumably due to interstitial hemorrhage at recent delivery. Such deposits were found in only one other female (Control Group II) whom we suspect to have delivered recently but who was not recorded as lactating.

Experimental Groups

Group VI, Nonpregnant Animals With Corpus Luteum

The 58 animals of this group were not detected to be pregnant at sea but had a corpus luteum present in one of their ovaries. The group is divided into three subgroups made up of specimens with corpora lutea at different stages of development or involution.

Group VIa: These 28 animals (19, S.l. and 9, S.a.) measured 163 - 191 cm in length and the group was of special importance because the corpora lutea were adjudged to be the youngest. For this reason, an early pregnancy could have been overlooked. Two intact uteri were dissected meticulously, including the fallopian tubes, however, embryos or placentas were not identified in any of the 28 specimens. From the dates of capture (Table 7) it will be noted that

the majority (17) were captured in February, as is also true of early pregnant animals (Table 4). These figures must be interpreted with caution, however, because of different catch sizes on various cruises. The macroscopic findings were not uniform in that uterine weight varied between 90 and 467 g, the horn sizes varied considerably and endometrium was as often congested or mucus covered as not. Only once was the corpus luteum found in the right ovary.

The histologic appearance of the endometrium correlated neatly with the corpus luteum (CL) development and grouping was undertaken accordingly. Those specimens whose CL had a central fibrin-filled cavity were placed into Group VIa; those whose cavity was replaced by fibrous tissue were adjudged to have ovulated earlier and placed into Group VIb. Because of the potential insight these specimens give into the dynamics of ovarian/endometrial relationships, these specimens are described in more detail.

When the Graafian follicle has recently ruptured, stromal vessels infiltrate the granulosa layer (Figure 16). The follicular lumen is filled with serous fluid and fibrin but rarely contains blood as in many other species. The corresponding endometrial stroma is edematous, the glands are tubular, lack secretory vacuoles and contain mitoses (Figure 17). When the CL is better established, the central cavity is more pronounced, capillaries have penetrated the granulosa layer and, in contrast to its cells in specimens from early pregnancy (Figure 11) they possess less cytoplasm, being less plump (Figure 18). It should again be noted that the cavities rarely contain red blood cells. The endometrial glands at this stage are more crowded, have more coiling and still possess mitoses but the earliest appearance of epithelial cytoplasmic vacuoles occurs (Figure 19). The vacuolization appears to commence under the endometrial surface and penetrates slowly throughout the entire thickness of the endometrium (Figure 20). At the same time, fibroblastic

infiltration of the CL cavity has taken place and the luteinized cell wall has folded remarkably. Very few mitoses were found in superficial endometrial cells at this stage and in the final stages before the central CL cavity has been completely filled in by fibrous tissue, the endometrial stromal edema disappears, to be replaced by coiled secretory glands (Figure 21). No mitoses exist, nor is secretion exuded into the glandular lumina. Such corpora lutea are expected to be associated with early pregnancy particularly because of the conspicuous size of granulosa luteal cells. Since no embryonic sacs were found it is then also not surprising that the endometrium possesses different histologic features from those whose comparable corpora lutea were associated with early pregnancy (Figures 11 - 13). Perhaps this climaxes endometrial development before regression of corpus luteum occurs.

One of these specimens from an October catch (#20, Table 6) had a fresh CL with fibrin-filled cavity and unusual endometrium. The stroma beneath the surface epithelium had the typical hyalinization of the post partum state, yet, early secretory endometrium was found in deeper layers (Figure 22). Moreover, hemosiderin pigment was found. It would appear that this was the first and infertile ovulation after a recently past pregnancy which is further supported by the marked discrepancy of the uterine horns (29 cm left; 18 cm right).

Group VIb: These 15 animals (11, S.l. and 4, S.a.) had well-established corpora lutea with completely organized cavities, the luteal cells appeared well-supported, and they were found to be nonpregnant (Table 8). Their lengths varied from 169 - 198 cm and uterine weights were between 110 and 580 g. One of these specimens had not been opened, was carefully dissected by us and found to be nonpregnant. Again, the majority (12) were from February catches, many uteri had stretch marks from former pregnancy, and in two ovaries the corpus

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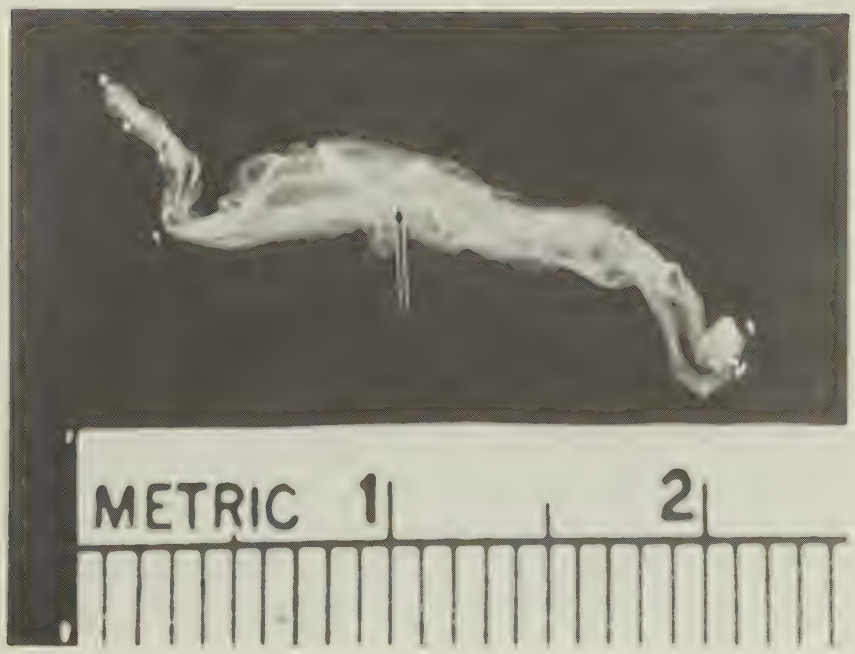

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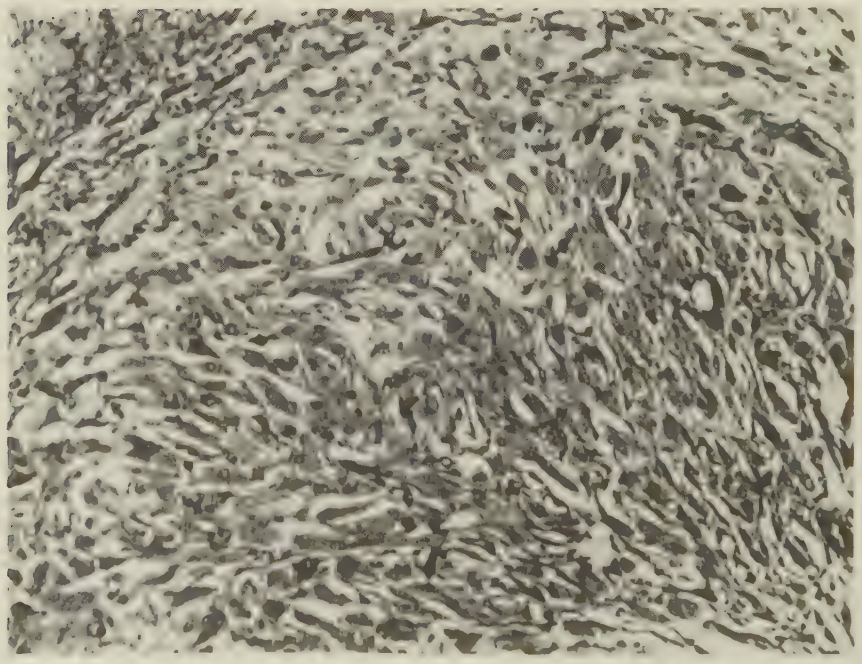

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luteum was found on the right.

The secretory endometrium of almost all these specimens showed great similarity with those shown in Figures 20 and 21. The amount of edema varied slightly and so did the glandular vacuolization. No secretion was found within the glands although frequently there was thick mucus covering the endometrial surface on gross examination. The luteal cells were supported, not degenerated but less plump than in early pregnancy. The only difference was the complete fibrosis of the central cavity, probably insufficient findings for a meaningful separation of some specimens from the previous group VIa. Of course, no capillary proliferation of the superficial endometrium, so typical of pregnancy, was evident.

One specimen is probably misclassified (#15, Table 8). Not only is this the largest uterus (580 g) with pronounced stretch marks (Figure 23) but also it exhibits a differing histologic appearance of the endometrium (Figure 24). This shows acute endometritis in a mucosa which otherwise had all of the characteristics of pregnancy. The CL was well-supported with large plump cells. In all likelihood the dolphin (S.a.) had very recently delivered. This is from a November catch and it is impossible to determine whether this represented a full term pregnancy since Perrin et al. (1976) showed that calving does occur in this species in the winter, although less commonly. It may well be that this inflammatory exudate in the superficial endometrial regions represents the normal immediately post partum event. This would explain the persistence of an active corpus luteum, presumably destined to involute shortly.

Group VIc: This comprises 15 animals (8, S.l. and 7, S.a.) measuring 162 - 193 cm whose features are listed in Table 9. These nonpregnant dolphins possessed histologically regressing corpora lutea. Eight animals in fact had

corpora albicantia and were probably misclassified by the gross observers because the CL in each case was recently involuted, had still some vascularization and microscopic inflammation. Similarly, the endometria in these specimens usually had inflammation and hyalinization and were most likely recently delivered. This is further suggested by the disparity in uterine horns. These animals were not listed as lactating either because this feature had been overlooked or perhaps the calves had died or were aborted. This material does not allow this differentiation.

Six of the remaining 7 animals had CL with histologic signs of early degeneration. Two had late secretory endometrium and this would likely to have involuted upon further regression of the CL since pregnancy did not occur. Two animals had marked chronic endometritis. Two others had marked endometrial stromal edema in addition to having horns of different lengths. The possibility of abortion exists in these animals but this cannot be proven. Finally, one animal of this heterogeneous group (#12, Table 9) had equal uterine horns (18 cm) and possessed corpora albicantia in addition to a degenerating right-sided CL. The endometrium with hyalinization and capillary development suggested recent pregnancy but because of the size of the uterus (205 g) it appears likely that a recent right-sided pregnancy had ended in abortion.

DISCUSSION

At present it is unknown whether dolphins ovulate spontaneously or upon reflex after copulation. Some reasons to believe the latter have been presented for Tursiops truncatus (Harrison 1977) and the same is inferred for other cetacea. The finding of corpora lutea almost exclusively in pregnant animals is the basis for this assumption and the purpose of this study was to

examine the genital tracts of 58 nonpregnant animals with corpora lutea in detail in an attempt to resolve this question. Although conclusive proof is lacking the results suggest that dolphins may ovulate spontaneously at least at times. Control material of different reproductive phases (96 specimens) of the two species of dolphin investigated, the Eastern spinner dolphin, Stenella longirostris, and the spotted porpoise, Stenella attenuata, provided a life history of the macroscopic and microscopic events in the uteri and ovaries of these species for the first time. The principal findings were the following: In 3 immature animals neither corpora lutea (CL) nor corpora albicantia (CA) were present in the ovaries but Graafian follicles were forming. The endometrium had tubular glands. In 6 mature animals without CL all were found to have one or more CA, the horns were disparate in size, 5 had stretch marks as an excellent sign of former pregnancy, in most the inactive endometrium possessed inflammatory cells, hyalinization and hemosiderin macrophages as indications of former pregnancy. Eleven of 12 early pregnant animals with embryonic sizes of 1 - 53 mm had the pregnancy in the left horn, one in the right on which side also the CL was located. The endometrium of the earliest pregnancy had characteristic changes that should allow pregnancy diagnosis even if the embryo is overlooked or lost. Six late pregnant specimens had their CL in the left ovary, typical epitheliochorial implantation and again characteristic endometrial histology. Eleven lactating females were studied, none of which had a CL but all possessed at least one CA which was in various stages of degeneration. The endometrium showed typical regressive changes with hyalinization, chronic inflammation and hemosiderin. These features will also allow categorization of uteri from females with unknown reproductive state in future studies. Of the 58 animals with macroscopically diagnosed corpora lutea and no

detectable pregnancy only 43 in fact had an active CL, the remaining 15 specimens had corpora albicantia in various stages of regression. Three CL were on the right, the remaining 40 were on the left, confirming the usual finding of cetacea that the left side predominates in reproduction. When a correlation was sought between the development of the corpus luteum and endometrial changes a well-delineated cycle of proliferation and edema to secretory stages emerged. No changes indicative of early pregnancy were seen and three intact uteri contained no embryos. Thus, clearly ovulation does occur without pregnancy ensuing. In three specimens the correlations suggested abortion, 2 had marked endometritis. These latter findings are summarized in Table 10.

It would appear from these findings then that most often ovulation and CL formation in these two species of dolphins results in or is accompanied by pregnancy. The possibility that abortions of implanted pregnancies occur frequently can be ruled out from the histologic appearance of the endometria in the majority of the specimens from the experimental group. Embryonic wastage prior to implantation remains a possibility although no evidence can be adduced for this. Moreover, recent and as yet unpublished evidence in our laboratory (J. Sawyer) has identified hormonally spontaneous ovulation in a Delphinus female that was kept in isolation. Evidence for regression of such corpora lutea in nonfertile cycles was also found in our experimental group. It is possible then that either ovulation is induced in a majority of cycles or that a majority of dolphins become pregnant when ovulating. In either case, it is not likely that a count of corpora albicantia in dolphins' ovaries accurately reflects the number of past pregnancies. It would be useful to know from aquaria with accurate historical information and pathologic study at death whether older females that have been kept in isolation since youth

possess corpora albicantia. Inasmuch as the question of artificial insemination of exhibited animals has been raised in the past (Hill and Gilmartin 1977) it can be concluded that it would appear feasible without the need of superovulation.

From a practical standpoint it is suggested that the following points be considered in future studies. First it would have been helpful to have had a histologic sample of breast tissue and vagina in all specimens to enhance histologic correlations. Moreover, inasmuch as the hormonal cycle of Delphinus is now being defined by modern endocrine techniques undertaken longitudinally in captive specimens it may be useful for future studies to save for endocrine analysis an aliquot of frozen serum. Potentially, such a study would clarify the status of equivocal corpora lutea. At the same time storage of fetal serum would allow insight into the fetal endocrine behavior which is known to differ so markedly between species. Perhaps such comparative studies will ultimately give additional insight into the phylogenetic descendency of cetacea.

This study extends the sparse literature that exists on the morphology of the female reproductive organs. In general, the endometrial cycle is similar to that illustrated schematically for several whales (Slijper 1966) and for Globiocephala melaena (Harrison 1949). In this latter species Harrison (1949) also described the small superficial anastomosing vessels beneath the uterine epithelium and, in three recently ovulated specimens, he was unable to identify products of conception. In a later contribution, Harrison et al. (1969) suggest that while ovulation in Tursiops appears to be of a reflex nature, that of Stenella and Lagenorhynchus may be spontaneous as in Globiocephala. Our own findings cited above suggest, however, that in Delphinus spontaneous ovulation

occurs and one wonders whether this may not be the rule then in cetacea. A resolution can come only from longitudinal endocrine studies of isolated females from different species. As in most other studies of the morphology of cetacean reproductive organs, we observed no significant pathologic features in these specimens other than the endometritis described and occasional parametrial parasitic granulomata.

ACKNOWLEDGEMENTS

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TABLE 1. - Distribution of 58 reproductive tracts of those dolphins that were recorded to possess corpora lutea in the absence of pregnancy or lactation (Group VI).

1975		1976		1977	
S.l.	S.a.	S.l.	S.a.	S.l.	S.a.
0	2	38	15	0	3

TABLE 2. - Group I: Control - immature.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial fold mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm
1	S.l.	02/20/76	176	47	10	9	1.49	0.60	0.54	2.09	0.75	0.60
2	S.l.	02/20/76	168	44	9	9	1.34	0.39	0.60	1.07	0.36	0.62
3	S.l.	02/20/76	164	22	9	7	1.10	0.60	0.42	1.07	0.36	0.54
					Average in mm		1.31	0.53	0.52	1.41	0.59	

TABLE 3. - Group II: Control - mature.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm
1	S.l.	02/18/76	186	108	13	10	1.79	0.75	1.49	1.94	0.66	1.49
2	S.l.	02/14/76	181	123	17	15	2.70	0.75	1.04	2.24	0.90	0.90
3	S.l.	02/15/76	179	136	13	11	1.79	0.66	1.19	1.19	0.75	1.64
4	S.l.	02/14/76	178	152	17	8	2.99	0.90	2.39	4.78	0.90	1.94
5	S.l.	07/03/76	175	98	16	18	1.64	0.30	0.90	1.49	0.60	1.49
6	S.l.	06/03/76	173	110	23	18	4.18	0.90	1.49	3.58	1.04	1.49
						Average in mm	2.52	0.71	1.42	2.54	0.81	1.49

TABLE 4. - Group III: Control - early pregnant.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Fetus Length mm	Fetus Weight g
1	S.l.	02/16/76	176	140	10	15	6.87	1.49	1.49	5.37	1.49	1.49	1	1
2	S.l.	02/20/76	172	171	20	12	-	-	-	5.67	1.19	1.49	2	1
3	S.l.	02/07/76	178	145	15	12	5.07	0.90	1.49	4.03	1.04	1.94	2	1
4	S.l.	02/10/76	181	208	28	20	2.69	1.19	0.96	2.69	0.90	0.78	5	1
5	S.l.	02/21/76	188	163	20	15	2.83	0.75	0.04	2.99	0.75	1.04	5	2
6	S.l.	02/23/76	172	192	19	12	5.97	1.19	1.04	6.87	1.79	1.49	5	2
7	S.l.	02/22/76	166	204	17	11	6.87	0.75	0.90	7.46	1.34	0.75	5	2
8	S.l.	02/21/76	176	212	25	15	5.37	1.49	1.04	3.88	0.60	1.19	5	2
9	S.l.	02/14/76	167	227	19	13	6.87	1.19	1.94	-	2.39	1.49	5	2
10	S.l.	02/10/76	184	229	28	15	2.09	0.36	1.04	3.58	0.90	1.19	5	2
11	S.l.	05/16/76	180	144	17	13	4.78	1.19	1.04	2.99	1.19	1.19	8	2
12	S.l.	02/20/76	180	187	23	16	1.04	0.35	0.90	2.09	0.30	0.90	53	5
						Average in mm	4.68	0.99	1.17	4.33	1.16	1.25		

TABLE 5. - Group IV: Control - late pregnant.

#	Species	Date of capture	Length cm	Weight of placenta and uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Fetus length mm
1	S.l.	10/14/76	197	617	-	-	-	-	0.60	-	-	0.75	300
2	S.l.	10/14/76	182	703	42	21	-	-	-	-	-	-	429
3	S.l.	10/13/76	165	700	60	26	2.69	0.60	0.75	5.97	1.49	1.19	557
4	S.l.	10/13/76	168	982	64	20	1.79	0.60	0.60	-	-	-	725
5	S.a.	07/19/76	-	730	-	12	-	-	1.79	-	-	0.75	-
6	S.a.	07/19/76	-	965	-	21	-	-	2.08	-	-	0.60	-

TABLE 6. - Group V: Control - lactating.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Graafian follicles	Corpus albicans
1	S.l.	02/10/76	171	113	14	8	2.24	0.21	1.64	-	0.60	0.90	no	+
2	S.l.	02/07/76	182	112	13	9	2.29	0.57	2.54	2.99	0.66	1.04	+	+
3	S.l.	02/07/76	171	73	11	9	1.73	0.24	1.64	1.19	0.39	1.94	+	+
4	S.l.	06/25/76	171	65	12	11	1.34	0.30	2.99	1.79	0.30	2.09	no	+
5	S.l.	06/25/76	167	126	20	13	3.88	0.60	1.04	3.58	1.64	1.34	++	+
6	S.l.	02/10/76	174	74	15	8	1.79	0.60	1.49	2.24	0.75	0.90	no	+
7	S.l.	02/17/76	175	109	17	8	2.99	0.24	1.79	2.99	0.66	0.90	no	+
8	S.l.	02/19/76	174	198	21	13	7.91	0.90	2.09	6.87	1.13	1.19	no	+
9	S.l.	02/14/76	173	112	12	10	4.78	1.04	1.04	2.09	0.45	1.06	no	+
10	S.l.	06/30/76	173	60	13	12	1.49	0.75	2.09	1.19	0.60	0.75	+	+
11	S.a.	09/02/77	202	550	-	-	1.64	0.75	2.09	1.64	0.60	1.34	no	+
				Average in mm			2.92	0.56	1.88	2.66	0.71	1.22		

TABLE 7. - Group VIa: Experimental - early corpora lutea.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm
1	S.l.	02/14/76	184	120	15	19	5.37	1.72	1.04	2.69	1.04	0.75
2	S.l.	04/24/76	182	132	14	14	4.78	1.49	0.60	5.67	1.19	0.75
3	S.l.	02/07/76	171	-	26	16	4.18	1.49	1.34	4.48	1.34	0.60
4	S.l.	02/10/76	176	-	16	14	4.48	1.94	1.49	4.02	1.49	1.34
5	S.l.	02/11/76	173	-	16	18	2.84	1.19	0.45	-	-	0.75
6	S.l.	02/15/76	149	90	15	15	3.13	0.90	0.96	4.18	1.19	1.04
7	S.l.	02/13/76	180	119	25	13	6.56	0.75	1.34	4.18	1.04	1.04
8	S.l.	02/20/76	180	166	20	14	2.53	0.75	1.04	4.18	1.79	0.90
9	S.l.	02/20/76	184	217	25	20	4.48	1.49	1.19	3.28	1.40	0.90
10	S.l.	02/21/76	183	224	18	15	8.66	1.19	1.34	5.97	0.75	1.04
11	S.l.	02/20/76	181	167	16	14	4.48	1.19	1.94	5.97	1.04	0.90
12	S.l.	02/14/76	188	180	18	12	8.35	0.60	1.79	4.78	1.19	0.90
13	S.l.	08/08/76	163	127	16	12	8.96	0.90	0.90	4.48	1.49	1.19
14	S.l.	02/14/76	168	158	21	13	3.58	1.19	2.69	5.07	1.79	1.64

TABLE 7. - Continued.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm
15	S.l.	02/21/76	177	118	20	14	3.13	0.90	1.49	4.18	0.60	0.96
16	S.l.	02/19/76	167	111	17	15	3.28	2.09	1.04	3.58	1.79	0.75
17	S.l.	02/22/76	176	-	22	14	4.78	0.96	1.34	3.58	0.75	1.04
18	S.l.	02/22/76	171	-	14	11	4.18	1.64	1.19	3.28	1.49	1.04
19	S.l.	08/14/76	167	165	22	21	5.97	2.99	1.49	3.88	1.64	0.90
20	S.a.	10/11/76	174	190	29	18	3.88	0.60	1.49	3.28	0.84	2.09
21	S.a.	02/21/76	189	192	23	19	2.98	0.60	1.49	2.38	1.19	1.49
22	S.a.	08/24/76	176	390	35	15	7.46	1.49	1.64	-	1.19	1.49
23	S.a.	10/24/75	191	156	25	14	4.93	1.04	1.34	3.58	1.04	1.34
24	S.a.	08/20/76	174	333	26	16	7.16	1.79	1.94	2.99	0.75	1.19
25	S.a.	05/29/76	185	467	27	17	6.57	1.19	2.39	4.48	0.90	1.64
26	S.a.	04/27/76	180	154	18	20	4.18	1.19	0.90	3.28	1.79	1.04
27	S.a.	06/04/77	185	190	12	17	2.69	0.90	1.19	1.79	0.30	0.75
28	S.a.	06/30/77	186	220	13	12	2.84	0.90	0.90	2.39	0.45	1.49
						Average in mm	4.87	1.26	1.32	3.90	1.16	1.10

TABLE 8. - Group VIb: Experimental - well-supported corpus lutea.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm
1	S.l.	02/18/76	191	281	21	18	5.97	1.19	0.66	5.07	1.64	0.60
2	S.l.	02/18/76	169	-	17	14	2.23	1.64	0.90	1.94	1.19	0.84
3	S.l.	02/02/76	180	-	19	13	4.18	1.04	0.75	3.28	1.04	0.75
4	S.l.	02/21/76	184	142	18	16	7.16	0.84	1.49	6.57	1.49	1.79
5	S.l.	02/21/76	180	149	22	16	5.67	0.90	1.19	4.33	1.04	1.19
6	S.l.	05/26/76	178	268	24	19	4.48	1.04	1.94	2.84	0.75	1.34
7	S.l.	02/14/76	180	194	20	16	3.58	1.34	1.34	3.73	1.94	0.90
8	S.l.	02/20/76	178	227	21	13	4.18	0.75	1.19	3.28	1.19	1.04
9	S.l.	02/11/76	181	148	16	11	3.58	1.19	1.34	3.28	1.19	1.19
10	S.l.	02/06/76	170	117	18	15	4.48	1.04	1.04	3.88	1.04	1.49
11	S.l.	02/22/76	181	166	21	12	1.79	0.90	1.19	2.99	1.04	1.04
12	S.a.	02/17/76	193	250	24	23	5.67	2.09	1.34	2.84	1.19	0.90
13	S.a.	02/20/76	184	110	11	10	3.28	0.90	1.04	4.18	0.90	0.84
14	S.a.	06/04/77	185	240	22	17	2.39	1.19	1.79	1.79	0.60	1.88
15	S.a.	11/07/75	198	580	37	21	5.67	1.49	2.09	6.87	1.49	2.39
						Average in mm	4.29	1.17	1.29	3.79	1.18	1.21

TABLE 9. - Group VIc: Experimental - degenerating corpora lutea.

#	Species	Date of capture	Length cm	Weight uterus g	Length left horn cm	Length right horn cm	Endometrial fold mm	Endometrial valley mm	Myometrium mm	Endometrial fold mm	Endometrial valley mm	Myometrium mm
1	S.l.	09/11/76	162	250	32	15	5.22	1.19	2.24	3.88	1.19	1.64
2	S.l.	02/14/76	175	252	25	12	10.14	2.09	1.19	-	-	1.04
3	S.l.	05/26/76	183	273	25	15	4.93	1.04	1.19	3.88	1.19	1.04
4	S.l.	02/27/76	179	-	23	14	4.78	0.90	1.19	4.48	1.94	1.34
5	S.l.	02/21/76	185	-	21	16	2.09	0.90	0.90	1.19	1.04	0.75
6	S.l.	02/21/76	186	-	22	16	2.24	0.75	0.90	1.04	0.45	0.90
7	S.l.	02/17/76	186	291	25	14	5.37	1.19	1.34	3.58	0.90	1.04
8	S.l.	03/00/76	189	197	17	13	5.37	1.19	1.64	3.28	1.04	1.04
9	S.a.	08/23/76	172	145	-	-	1.64	0.45	0.90	2.09	0.60	0.60
10	S.a.	02/27/76	180	122	18	15	5.79	1.34	1.64	6.57	1.19	1.04
11	S.a.	02/26/76	185	-	23	18	3.13	0.90	1.34	2.39	0.60	1.04
12	S.a.	05/26/76	191	205	18	18	4.18	0.75	1.79	2.39	0.60	1.79
13	S.a.	06/00/76	193	375	22	15	8.80	1.94	2.09	6.42	1.79	1.79
14	S.a.	08/23/76	179	356	30	16	6.57	1.04	1.79	5.07	0.75	0.90
15	S.a.	04/19/76	185	305	25	13	4.18	0.90	1.49	3.28	0.90	1.64
					Average in mm		4.96	1.10	1.44	3.52	1.01	1.26

TABLE 10. - Group VI: Summary (experimental, nonpregnant).

38		Stenella longirostris
19	(50%)	Very fresh corpus luteum
11	(29%)	Well-established corpus luteum
8	(21%)	Degenerating corpus luteum - wrong gross diagnosis (2 endometritis; 2 unimplanted abortion?)
20		Stenella attenuata
9	(45%)	Very fresh corpus luteum
3	(15%)	Well-established corpus luteum
1	(5%)	Misclassified, recently delivered
7	(35%)	Degenerating corpus luteum - wrong gross diagnosis (1 recent abortion?)

LIST OF FIGURES

FIGURE 1: Diagram of dolphin uterus. Arrows indicate locations and nature of measurements; squares denote location of histologic sections examined.

FIGURE 2: Immature uterus of S.1. (#1, Table 2). Note the flat folds of endometrium, equal-sized horns and lack of serosal stretch marks (center).

FIGURE 3: Endometrium of immature S.1. (#3, Table 2). Tubular glands, little folding, thin endometrium, no secretion or mitoses (H&E x60).

FIGURE 4: Mature animal's uterus, presumably recently delivered (#4, Table 3). Note larger left horn with congestion and serosal stretch marks.

FIGURE 5: Corpus albicans of animal in Figure 4. At right is former follicular cavity, replaced by young fibroblastic tissue. Dark cells in central (former luteal) band of CA suggest recent conversion of CL to CA (H&E x120).

FIGURE 6: Endometrium of animal in Figures 4 and 5, surface at right. Infiltration of stroma with macrophages; sparse glands; hyalinization of stroma and larger vessel walls at H. (H&E x120).

FIGURE 7: Endometrium undergoing early stimulation, presumably after past pregnancy (3#, Table 3). Glands are more numerous and coiled. They contain occasional epithelial secretory vacuoles and mitoses. Focal edema (E) of stroma commences (H&E x60).

FIGURE 8: Early pregnant uterus with distended left horn and hyperemia of endometrium (#4, Table 4).

FIGURE 9: Smallest (2 mm) normal embryo at arrow with long, filmy placental membranes (#3, Table 4).

FIGURE 10: Five mm embryo (arrow) with huge placental membranes (#9, Table 4).

FIGURE 11: Portion of active corpus luteum of earliest pregnancy with

cavity at bottom right and ovarian stroma (S) at top left. (#3, Table 4; H&E x100.)

FIGURE 12: Endometrium of earliest pregnancy (Figures 9 and 11; #3, Table 4). Uterine lumen (L) at right. Note the marked edema (E) in superficial stroma, congestion (C) and compact arrangement of secretory glands at left (H&E x50).

FIGURE 13: Typical capillary distension (arrows) and neovascularization of endometrial stroma immediately beneath surface endometrial epithelium in early pregnancy (#9, Table 4; H&E x300).

FIGURE 14: Placental attachment with basal endometrial glands (G) at left and interdigitating villi (V) within distended glandular lumina (#2, Table 5; H&E x80).

FIGURE 15: Corpus luteum of uterus shown in Figure 14, the organized cavity is at bottom right. Note well-supported dark luteal cells with fibrocytes in between (H&E x150).

FIGURE 16: Very fresh corpus luteum with focal hemorrhages (left), luteinized granulosa cells (LG) infiltrated by capillaries (arrows) sprouting from the ovarian stroma (OS) (#18, Table 7; H&E x400).

FIGURE 17: Endometrium of specimen in Figure 16 with glandular mitosis at arrow. Note stromal edema (H&E x400).

FIGURE 18: Young corpus luteum in nonpregnant animal. Note central cavity (top) is filled with fibrin and granulosa layer is penetrated by capillaries (black). Size of granulosa lutein cells is much smaller than in Figure 11, an early pregnant specimen (#3, Table 7; H&E x100).

FIGURE 19: Endometrium of same specimen as Figure 18 to show increased glandular coiling and earliest appearance of light cytoplasmic vacuoles in dark

epithelial cells (H&E x100).

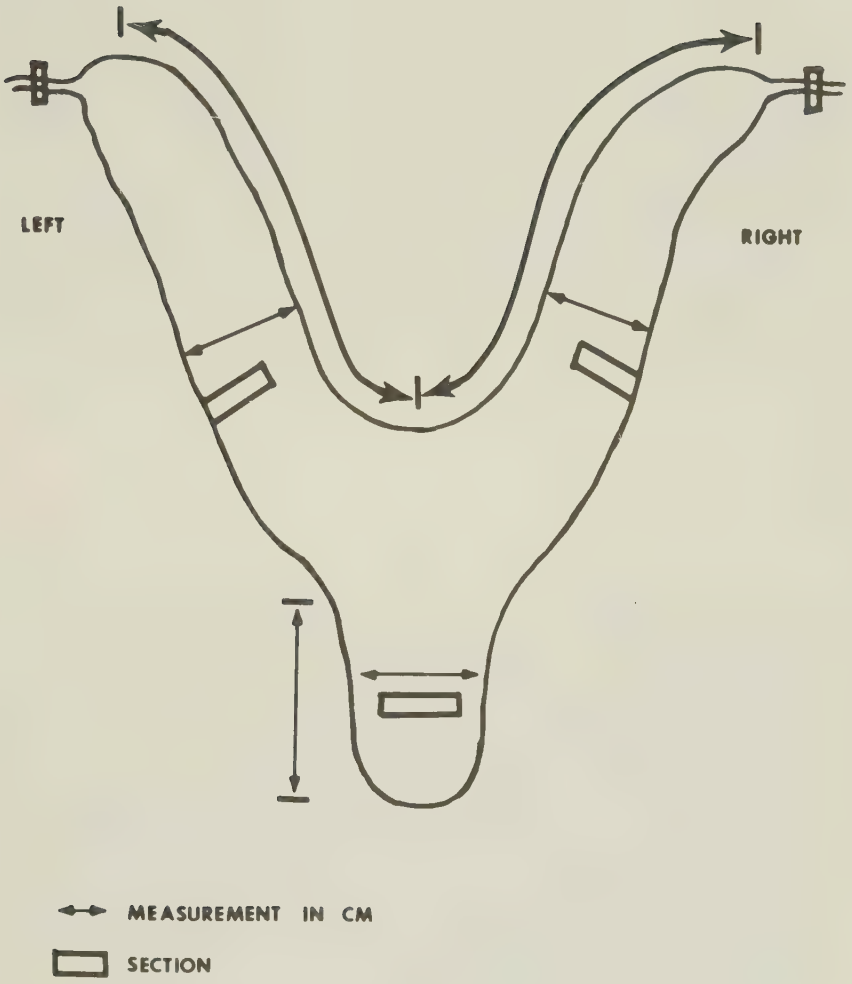
FIGURE 20: Endometrium of nonpregnant dolphin (S.l.) with well-established corpus luteum, to show secretory vacuoles in endometrial glands as well as stromal edema (#10, Table 7; H&E x100).

FIGURE 21: Final stages of secretory change in endometrium of nonpregnant dolphin (S.l.) with advanced corpus luteum. Crowding of secretory glands occurs in stroma that has now lost its edema. No secretion in lumen. Endometrial cavity at right. (#16, Table 7; H&E x100.)

FIGURE 22: Endometrium of presumably delivered dolphin (S.a.) whose ovary had a fresh corpus luteum. Endometrial cavity top left, hyalinized stroma (HyS) beneath surface epithelium and secretory glands (SG) beneath this layer (#20, Table 7; H&E x100).

FIGURE 23: Uterus of recently delivered Stenella attenuata, #15, Table 8. Note stretch markes of left horn, congestion and disparate size of horns.

FIGURE 24: Endometrium of uterus in Figure 23. The marked stromal edema (E) and distended glands (G) of basal endometrium are typical of late pregnancy. The superficial endometrium is infiltrated by polymorphonuclear leukocytes that exude into the glandular lumina (arrow). No surface stromal hyaliniz-tion has yet taken place. The former interdigitation of placental villi with surface endometrium can well be imagined from the irregularities the surface presents (H&E x100).



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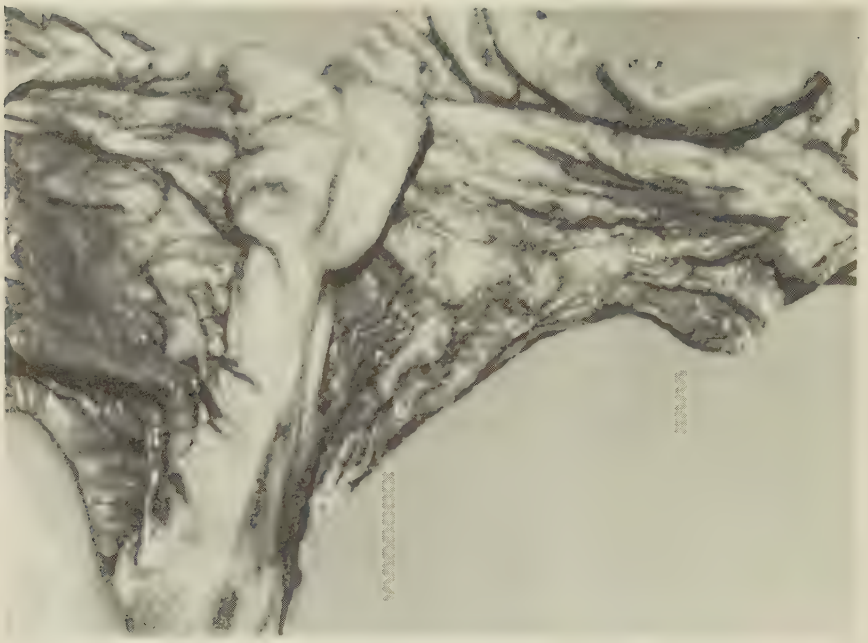

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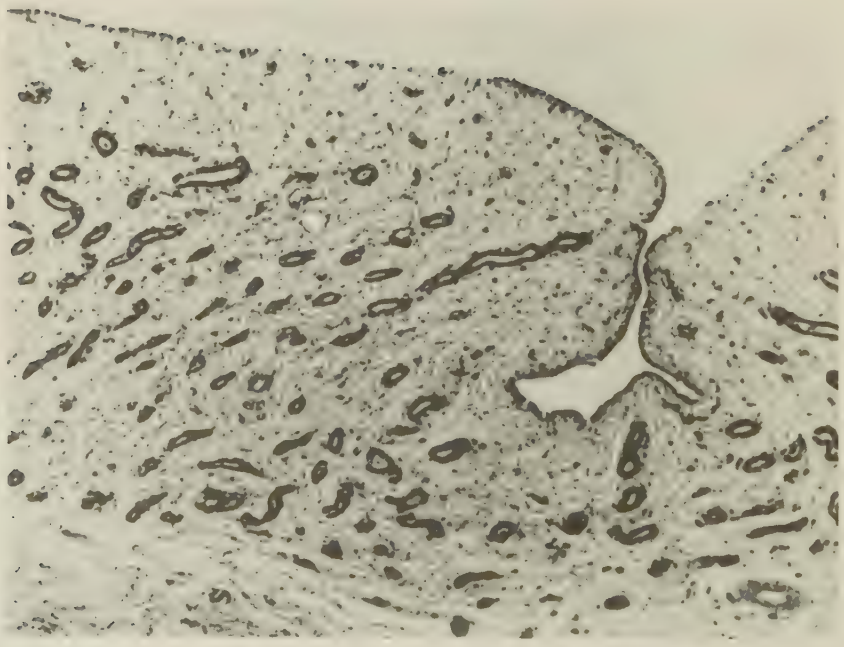

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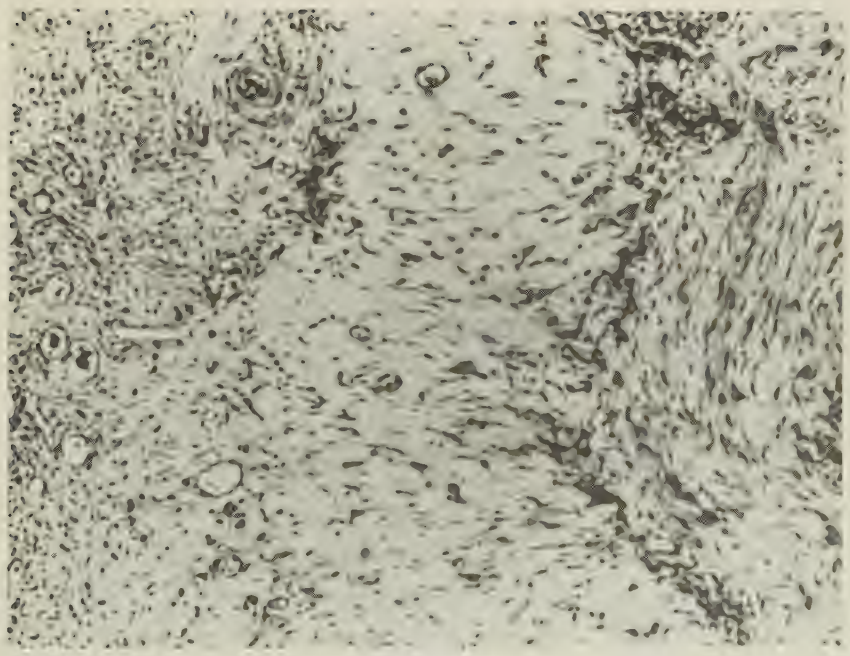

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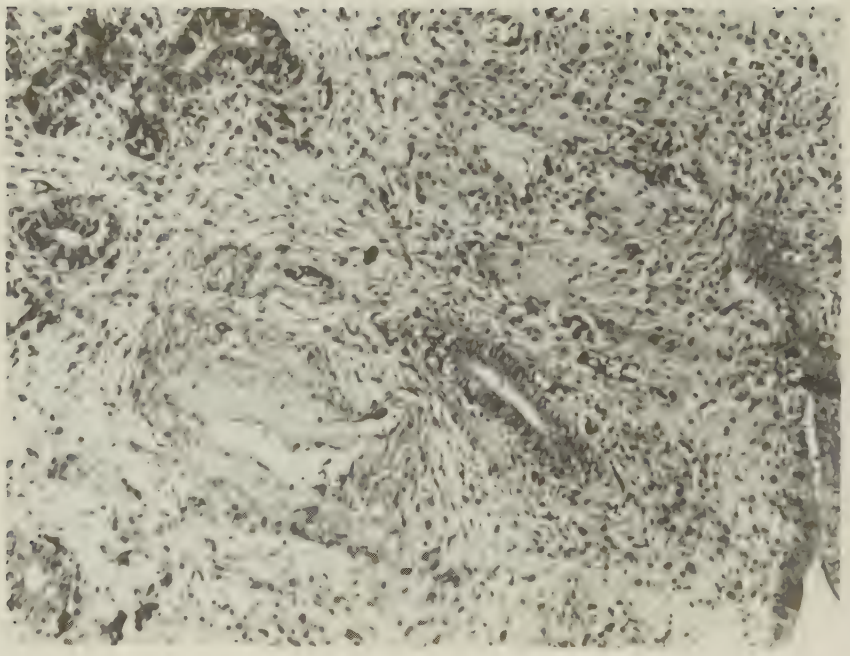

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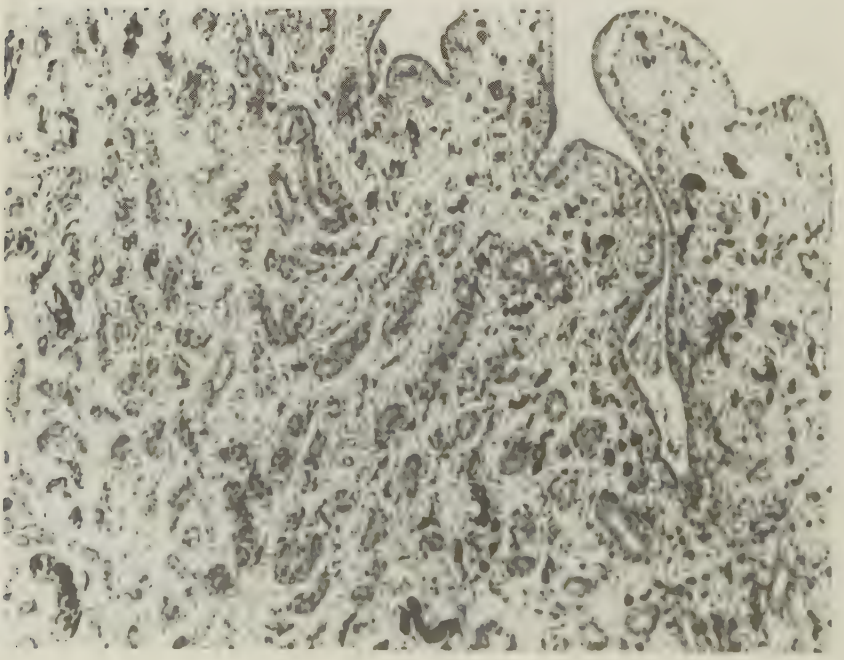

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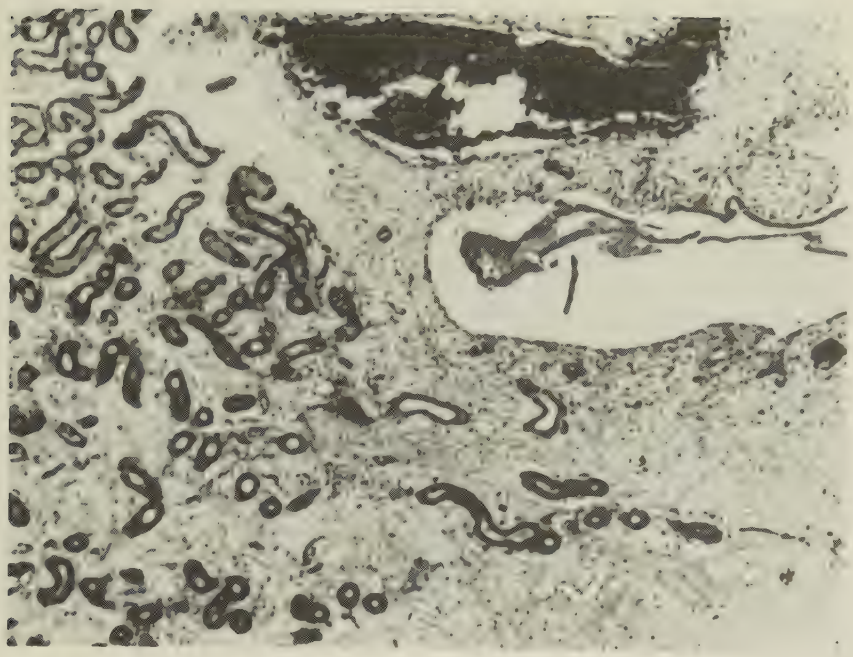

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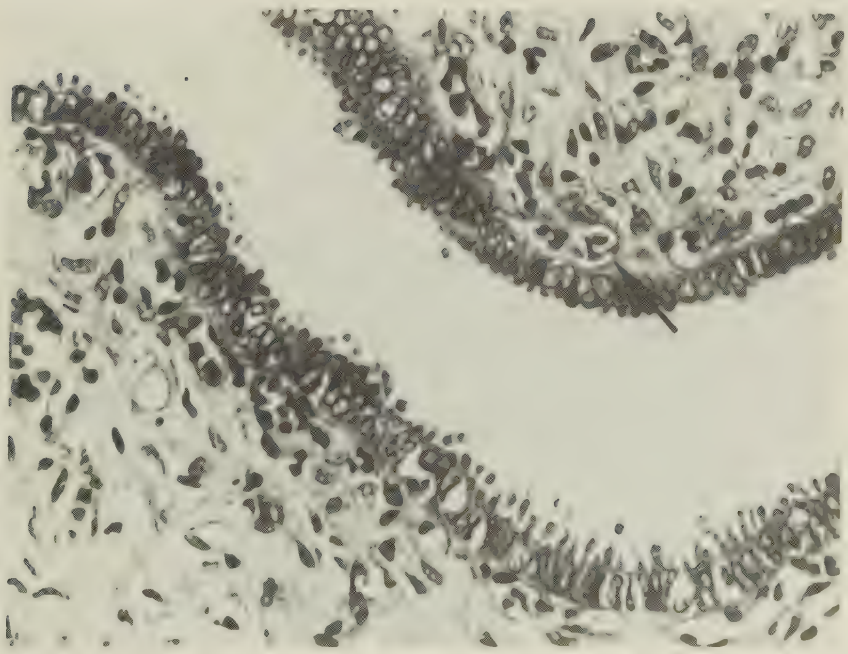

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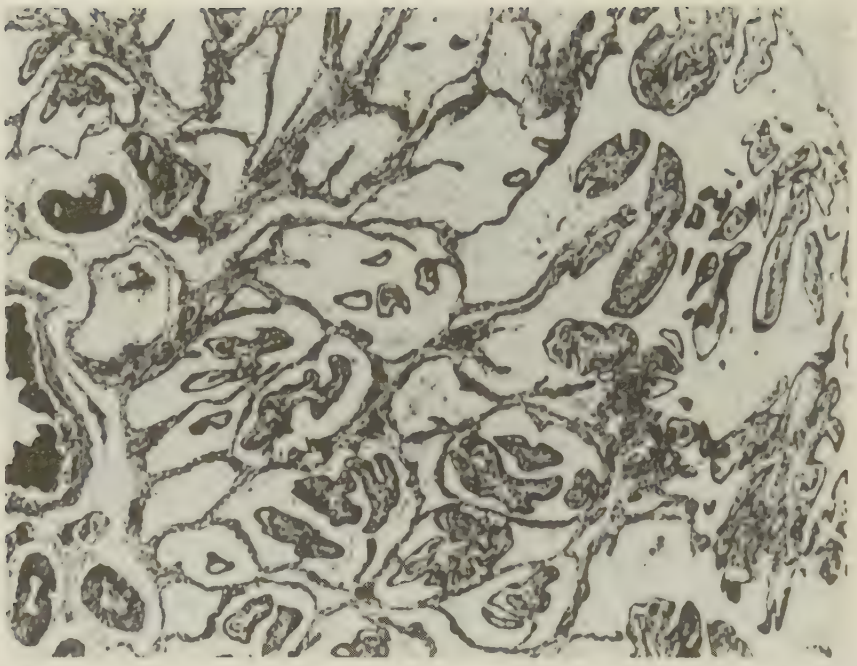

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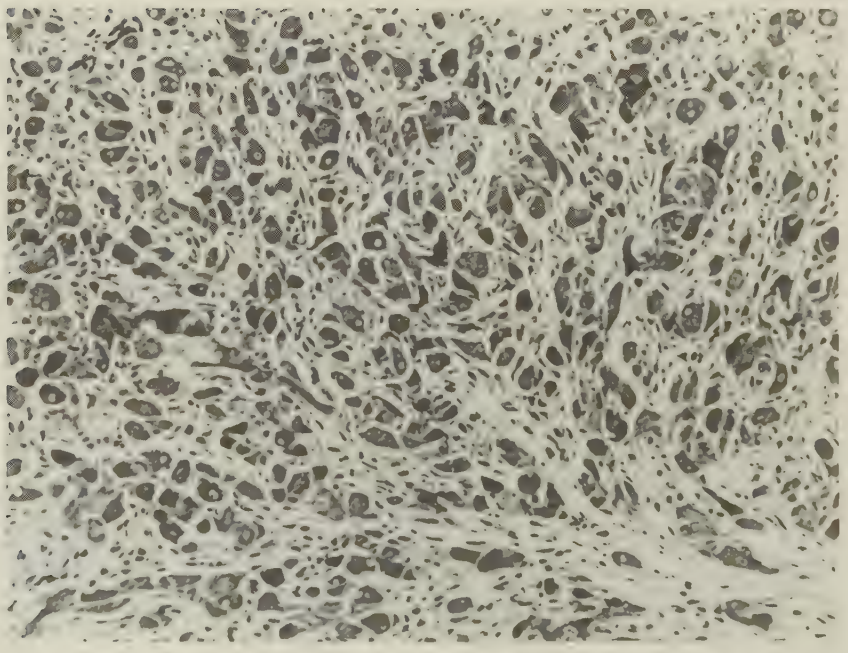

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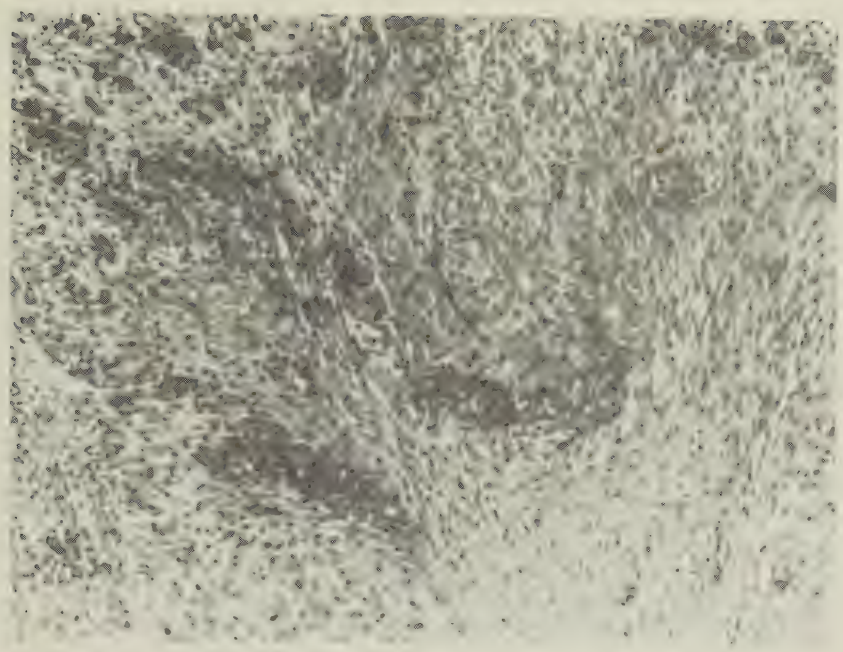

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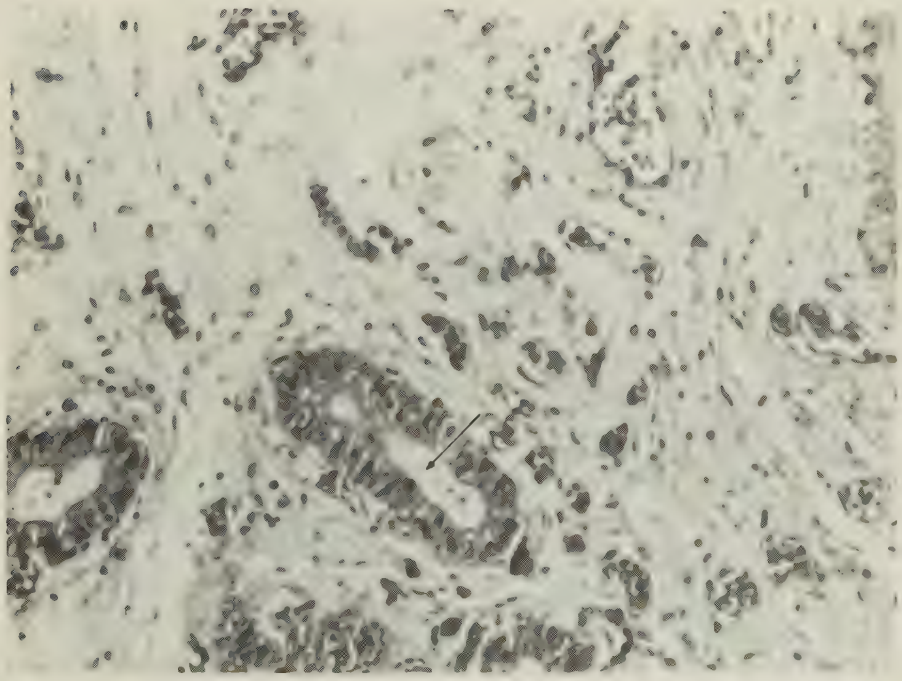

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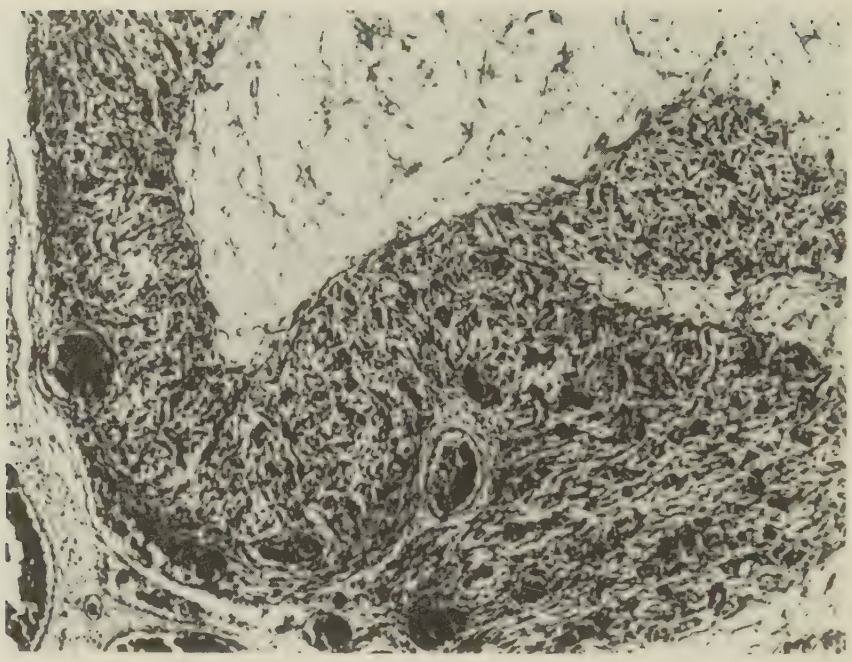

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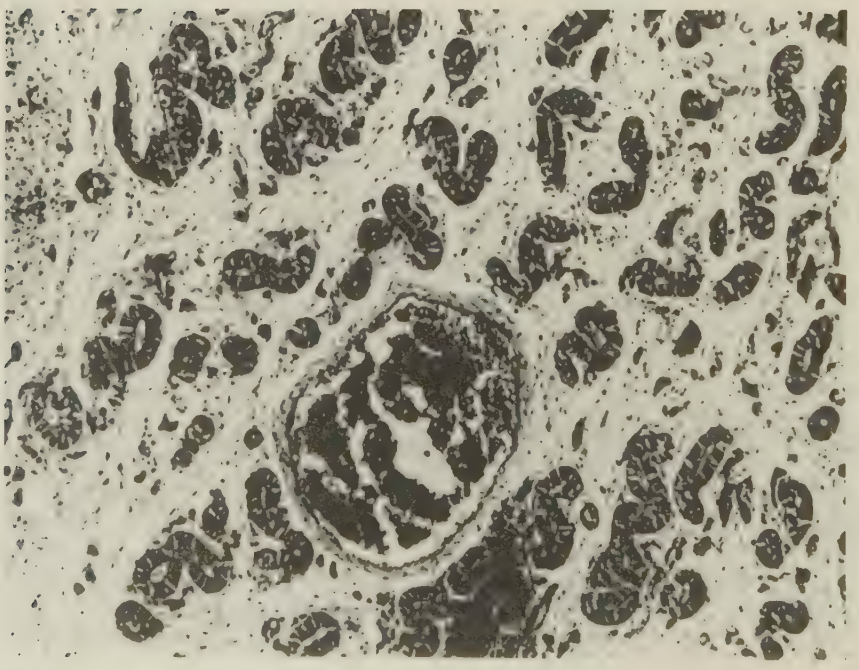

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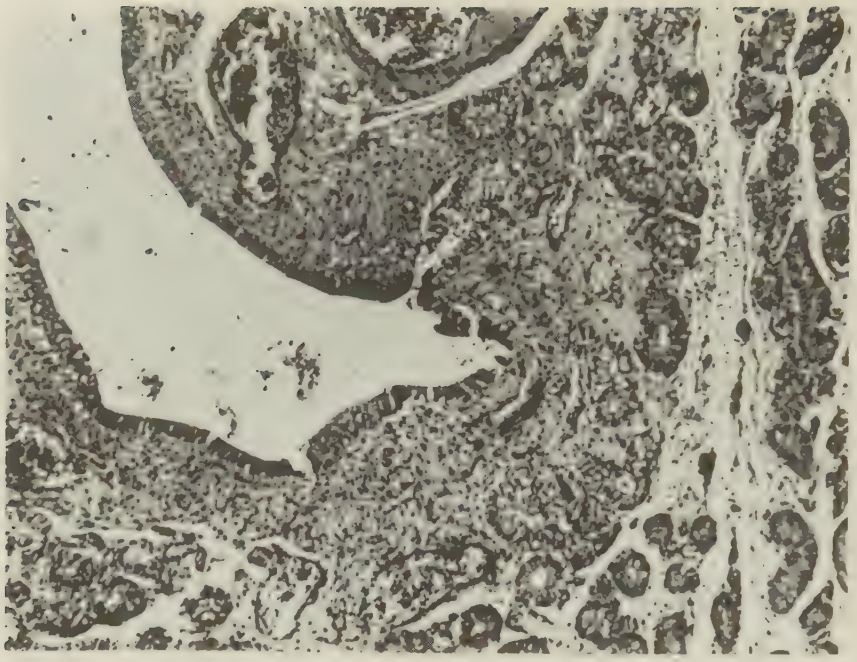

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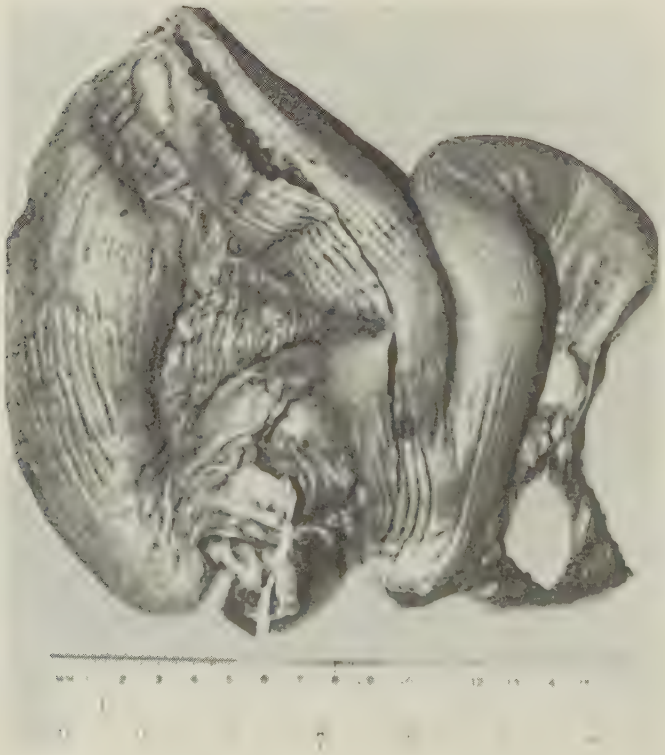

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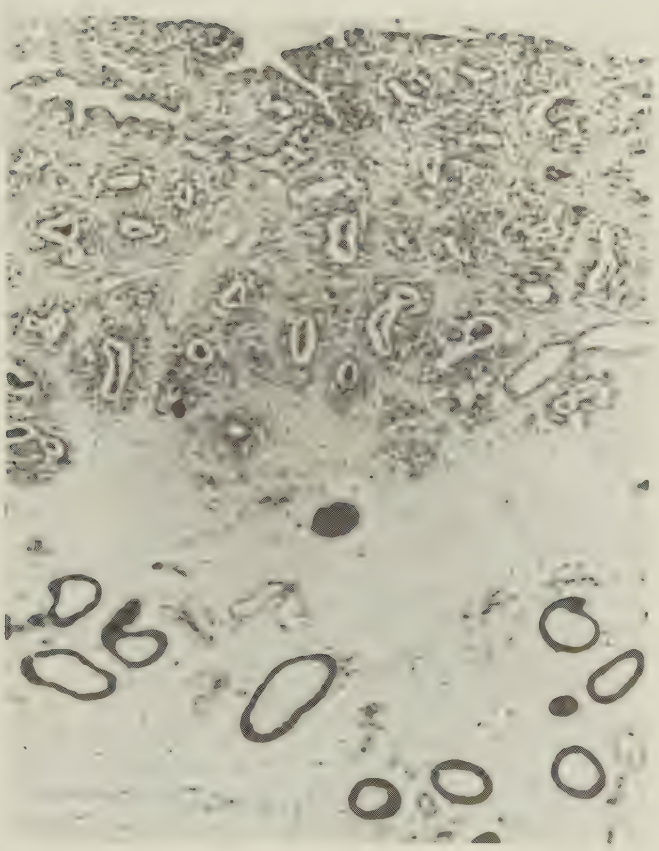

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